# MPLS in VPP

## Using Linux Control Plane

Pim van Pelt • 2024-04-19 • GRNOG 16 • Athens, Greece

# Intro: Pim van Pelt (PBVP1-RIPE)

Pim van Pelt
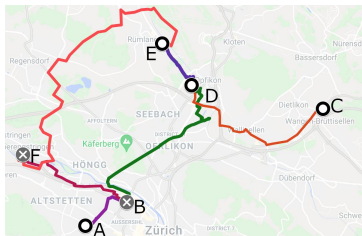
- Member of the RIPE community since 1999 (RIPE #34)

  - Has used [pim@ipng.nl] for 25 years

  - And also [pim@ipng.ch] for 18 years

  - Incorporated [ipng.ch] in Switzerland in 2021
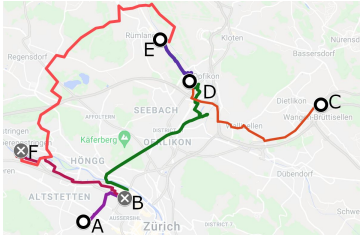
# Intro: IPng Networks - AS8298



- Developer of Software Routers - DPDK and VPP [ref]

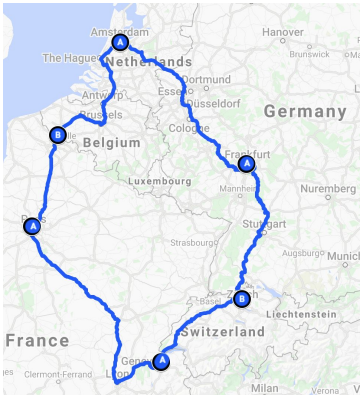- Tiny operator from Brüttisellen (ZH), Switzerland [ref]

# Intro: IPng Networks - AS8298





- Developer of Software Routers - DPDK and VPP [ref]

- Tiny operator from Brüttisellen (ZH), Switzerland [ref]

- Twelve VPP/Bird2 routers [ref] (UN/LOCODE names)

- European ring: *peering on the FLAP* * [ref] ~2'150 adjacencies

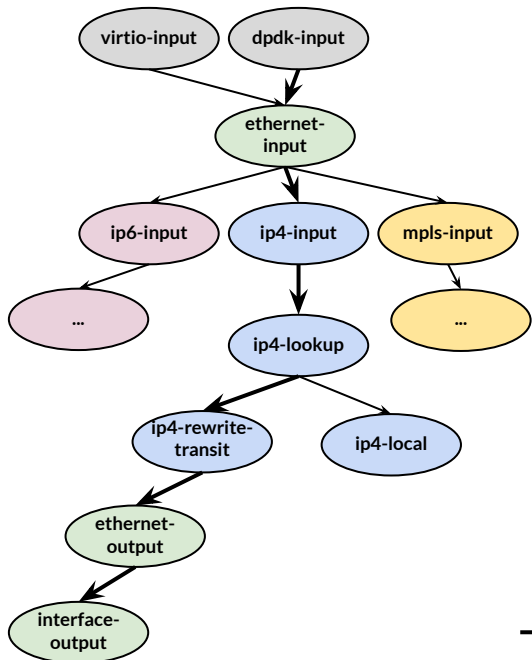- Acquired AS8298 from SixXS [ref]

# Intro: Vector Packet Processing

**VPP [ref] is an open source dataplane that can:**

- provide *very* fast networking
- using DPDK, RDMA, VirtIO, VMXNet3, AVF, …
- easily exceeds 100Mpps+ and 100Gbps+
- on commodity x86_64 / amd64 hardware!

See FOSDEM'22 [video] or DENOG #14 [video]

- Contributed to **Linux Control Plane** plugin [github]
- LinuxCP adds BGP/OSPF/VRRP/etc to VPP
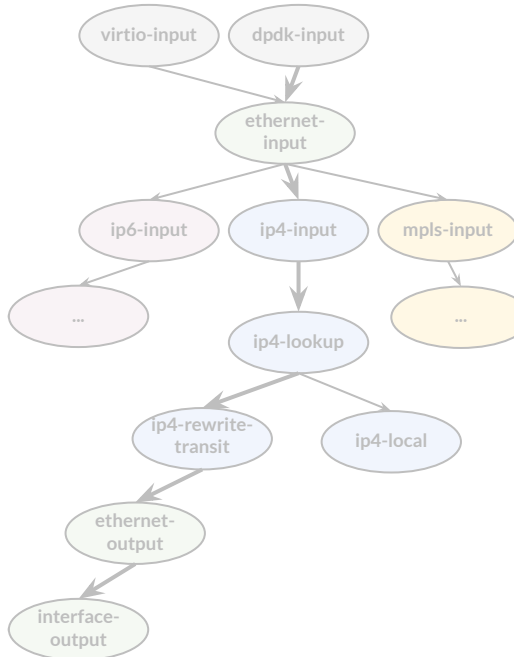- This talk discusses adding **MPLS support to LinuxCP**

*) Thanks to Pierre Pfister, Neale Ranns, Matt Smith and Jon Loeliger for the [collaboration]!
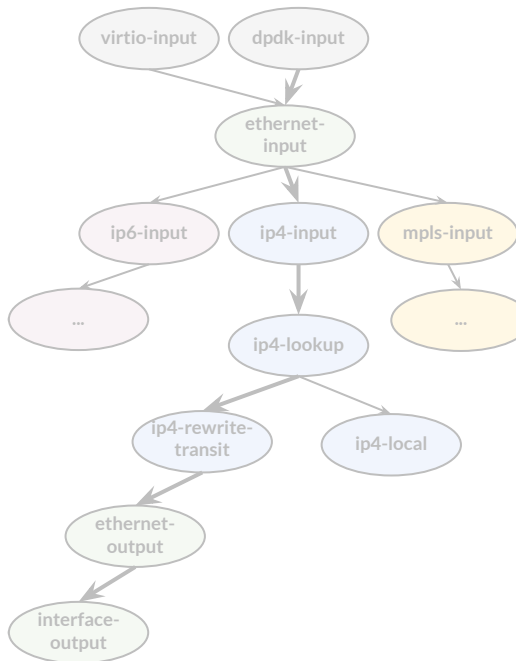
# Intro: VPP LinuxCP

```
pim@hippo:~$ vppctl lcp create HundredGigabitEthernet4/0/0 host-if ice0
```

# Intro: VPP LinuxCP

```
pim@hippo:~$ vppctl lcp create HundredGigabitEthernet4/0/0 host-if ice0

pim@hippo:~$ sudo ip link set ice0 up mtu 9000
pim@hippo:~$ sudo ip address add 2001:db8:0:1::2/64 dev ice0
pim@hippo:~$ sudo ip address add 192.0.2.2/24 dev ice0
```

# Intro: VPP LinuxCP



```
pim@hippo:~$ vppctl lcp create HundredGigabitEthernet4/0/0 host-if ice0
pim@hippo:~$ sudo ip link set ice0 up mtu 9000
pim@hippo:~$ sudo ip address add 2001:db8:0:1::2/64 dev ice0
pim@hippo:~$ sudo ip address add 192.0.2.2/24 dev ice0

pim@hippo:~$ sudo ip link add link ice0 name ipng type vlan id 101
pim@hippo:~$ sudo ip link set ipng mtu 1500 up
pim@hippo:~$ sudo ip addr add 2001:678:d78:3::86/64 dev ipng
pim@hippo:~$ sudo ip addr add 194.1.163.86/27 dev ipng
pim@hippo:~$ sudo ip route add default via 2001:678:d78:3::1
pim@hippo:~$ sudo ip route add default via 194.1.163.65
```
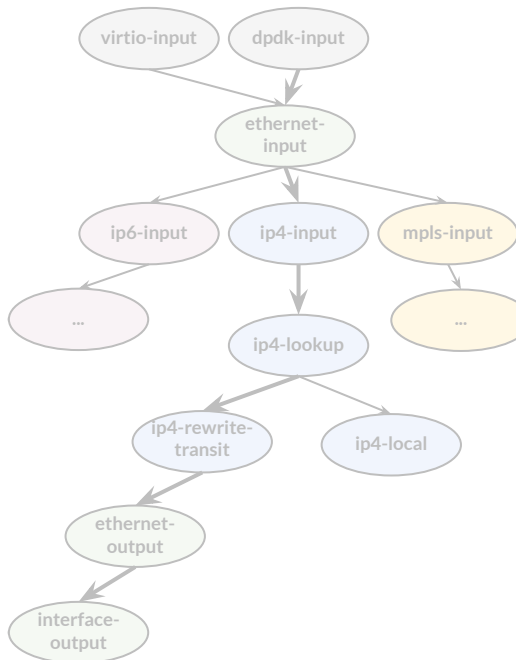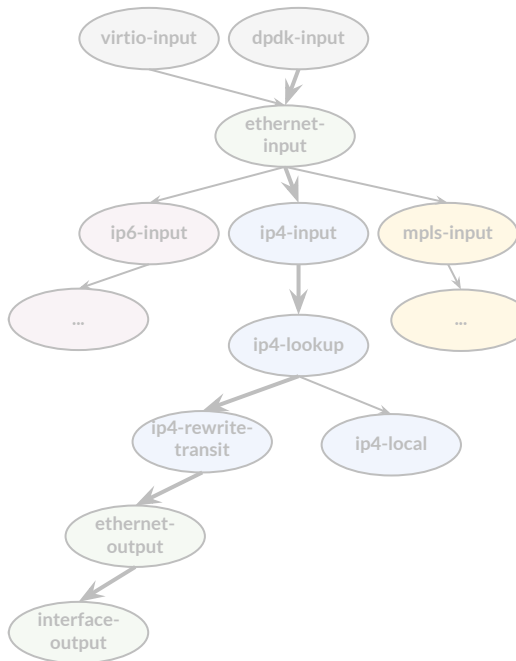
# Intro: VPP LinuxCP

```
pim@hippo:~$ vppctl lcp create HundredGigabitEthernet4/0/0 host-if ice0

pim@hippo:~$ sudo ip link set ice0 up mtu 9000
pim@hippo:~$ sudo ip address add 2001:db8:0:1::2/64 dev ice0
pim@hippo:~$ sudo ip address add 192.0.2.2/24 dev ice0

pim@hippo:~$ sudo ip link add link ice0 name ipng type vlan id 101
pim@hippo:~$ sudo ip link set ipng mtu 1500 up
pim@hippo:~$ sudo ip addr add 2001:678:d78:3::86/64 dev ipng
pim@hippo:~$ sudo ip addr add 194.1.163.86/27 dev ipng
pim@hippo:~$ sudo ip route add default via 2001:678:d78:3::1
pim@hippo:~$ sudo ip route add default via 194.1.163.65


pim@hippo:~$ ping6 grnog.gr
PING grnog.gr (2a00:8642:1000:1::3): 56 data bytes
64 bytes from 2a00:8642:1000:1::3: icmp_seq=0 hlim=56 time=17.596 ms
64 bytes from 2a00:8642:1000:1::3: icmp_seq=1 hlim=56 time=17.302 ms
…
```

# Act 1: MPLS and Linux CP in VPP

# VPP: Without MPLS

```
pim@lab:~$ traceroute vpp1-3.lab.ipng.ch
traceroute to vpp1-3 (192.168.11.3), 30 hops max, 60 byte packets
 1  e0.vpp1-0.lab.ipng.ch (192.168.11.6)  1.265 ms  1.211 ms  1.167 ms
 2  e0.vpp1-1.lab.ipng.ch (192.168.11.8)  2.123 ms  2.655 ms  2.543 ms
 3  e0.vpp1-2.lab.ipng.ch (192.168.11.10)  4.786 ms  4.671 ms  4.873 ms
 4  vpp1-3.lab.ipng.ch (192.168.11.3)  6.302 ms  6.201 ms  6.093 ms
```
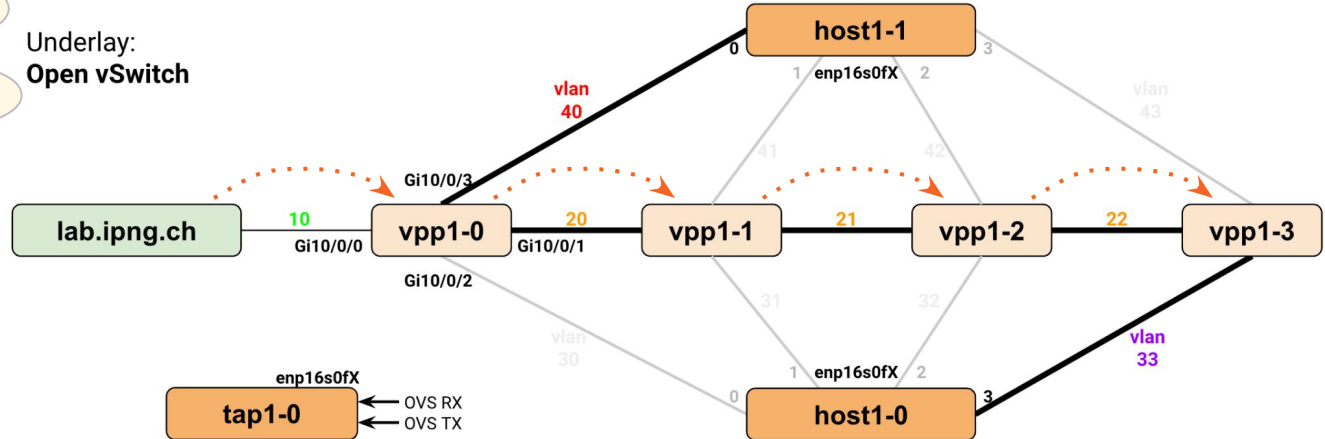


Underlay:
**Open vSwitch**

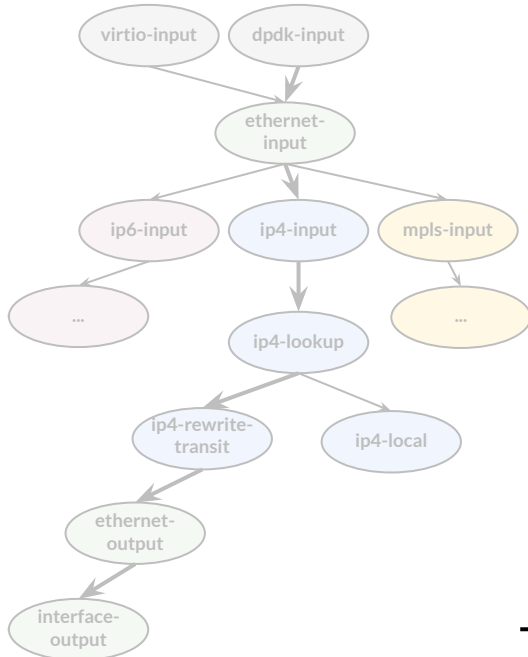# VPP: Linux Control Plane and MPLS

**Changes to Netlink Listener plugin:**

1. Add MPLS encap (PUSH) routes [gerrit]
2. Add MPLS fib (SWAP) routes [gerrit]
3. Add MPLS implicit/explicit-null (POP) [gerrit]

**Change to Linux Interface Plugin**

1. Add MPLS interface state change callback [gerrit]
2. Forward MPLS traffic from Linux [gerrit]

*) huge thanks to Adrian *vifino* Pistol for all his work

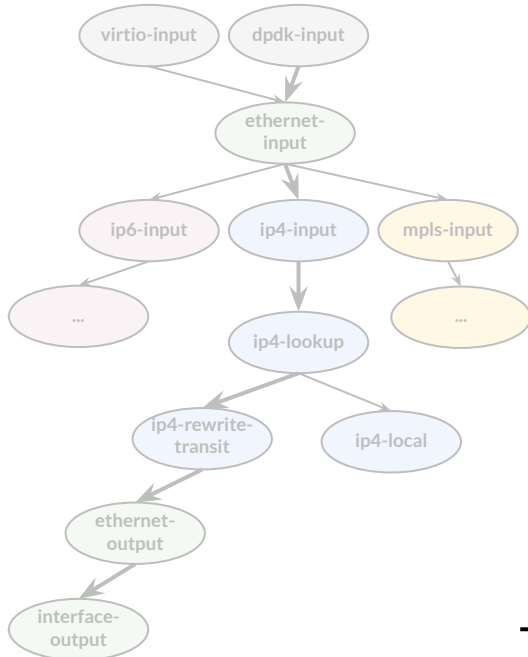# VPP: Linux Control Plane and MPLS (cont.)

**Detailed background and implementation notes:**

- [**Part 1**] - MPLS anatomy in VPP
- [**Part 2**] - MPLS Performance: LSP, Imp / Exp Null
- [**Part 3**] - Linux CP: POP, SWAP, PUSH
- [**Part 4**] - Linux CP: Cross connecting MPLS

**Resulting Code:**

- lcpng:  Merged in [github.com/pimvanpelt/lcpng]
- linux-cp: Merged upstream in Gerrit [38702]

# VPP: LinuxCP, MPLS and FRR

```
pim@vpp1-2:~$ vtysh -c 'show mpls ldp'
mpls ldp
 router-id 192.168.11.0
 dual-stack cisco-interop
 address-family ipv4
  discovery transport-address 192.168.11.2
  label local advertise explicit-null
  interface e0
  interface e1
 exit-address-family
 address-family ipv6
  discovery transport-address 2001:678:d78:210::2
  label local advertise explicit-null
  interface e0
  interface e1
 exit-address-family
exit
```

# MPLS: FRR View

```
pim@vpp1-2:~$ vtysh -c 'show mpls table'
Inbound Label   Type   Nexthop              Outbound Label
--------------------------------------------------------------------
16              LDP    fe80::5054:ff:fe13:1000  IPv6 Explicit Null
21              LDP    192.168.11.8             40
25              LDP    192.168.11.8             44
26              LDP    192.168.11.8             IPv4 Explicit Null
27              LDP    192.168.11.8             45
28              LDP    192.168.11.8             IPv4 Explicit Null
29              LDP    192.168.11.8             46
30              LDP    192.168.11.8             47
31              LDP    192.168.11.8             48
32              LDP    192.168.11.8             49
33              LDP    192.168.11.11            IPv4 Explicit Null
38              LDP    fe80::5054:ff:fe11:1001  25
42              LDP    fe80::5054:ff:fe11:1001  29
43              LDP    fe80::5054:ff:fe11:1001  IPv6 Explicit Null
```
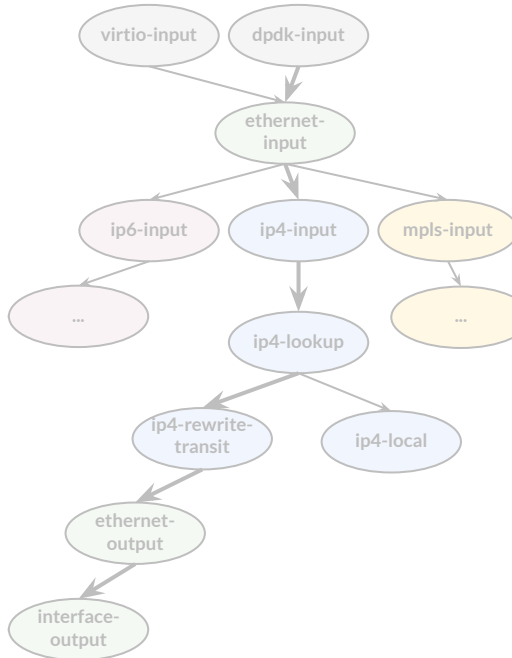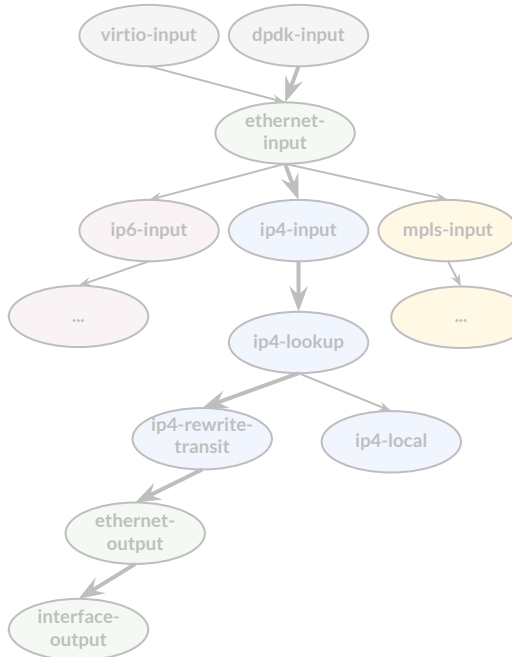
# MPLS: Linux view

```
pim@vpp1-2:~$ ip -f mpls ro
16 as to 2 via inet6 fe80::5054:ff:fe13:1000 dev e1 proto ldp
21 as to 40 via inet 192.168.11.8 dev e0 proto ldp
25 as to 44 via inet 192.168.11.8 dev e0 proto ldp
26 as to 0 via inet 192.168.11.8 dev e0 proto ldp
27 as to 45 via inet 192.168.11.8 dev e0 proto ldp
28 as to 0 via inet 192.168.11.8 dev e0 proto ldp
29 as to 46 via inet 192.168.11.8 dev e0 proto ldp
30 as to 47 via inet 192.168.11.8 dev e0 proto ldp
31 as to 48 via inet 192.168.11.8 dev e0 proto ldp
32 as to 49 via inet 192.168.11.8 dev e0 proto ldp
33 as to 0 via inet 192.168.11.11 dev e1 proto ldp
38 as to 25 via inet6 fe80::5054:ff:fe11:1001 dev e0 proto ldp
42 as to 29 via inet6 fe80::5054:ff:fe11:1001 dev e0 proto ldp
43 as to 2 via inet6 fe80::5054:ff:fe11:1001 dev e0 proto ldp
44 as to 30 via inet6 fe80::5054:ff:fe11:1001 dev e0 proto ldp
45 as to 2 via inet6 fe80::5054:ff:fe11:1001 dev e0 proto ldp
```
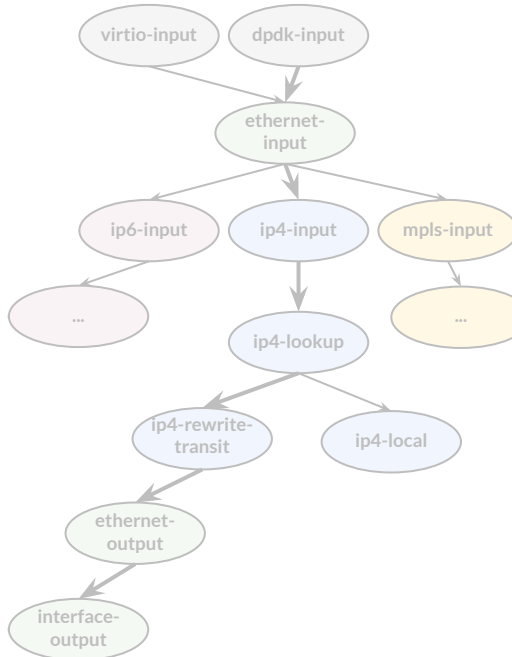
# MPLS: VPP view



```
pim@vpp1-2:~$ vppctl show mpls fib 21
MPLS-VRF:0, fib_index:0 locks:[interface:4, CLI:1, lcp-rt:1, ]
21:eos/21 fib:0 index:56 locks:2
  lcp-rt-dynamic refs:1 src-flags:added,contributing,active,
    path-list:[63] locks:36 flags:shared, uPRF-list:42 len:1 itfs:[1, ]
      path:[87] pl-index:63 ip4 weight=1 pref=0 attached-nexthop: oper-flags:resolved,
        192.168.11.8 HundredGigabitEthernet10/0/0
      [@0]: ipv4 via 192.168.11.8 HundredGigabitEthernet10/0/0: mtu:9000 next:6 flags:[]
525400111001525400121000800
    Extensions:
     path:87  labels:[[40 pipe ttl:0 exp:0]]
 forwarding:   mpls-eos-chain
  [@0]: dpo-load-balance: [proto:mpls index:59 buckets:1 uRPF:42 to:[0:0]]
    [0] [@6]: mpls-label[@53]:[40:64:0:eos]
      [@1]: mpls via 192.168.11.8 HundredGigabitEthernet10/0/0: mtu:9000 next:3
flags:[] 525400111001525400121008847
```

# MPLS: VPP view

```
pim@vpp1-2:~$ vppctl show mpls fib 21
MPLS-VRF:0, fib_index:0 locks:[interface:4, CLI:1, lcp-rt:1, ]
21:neos/21 fib:0 index:55 locks:2
  lcp-rt-dynamic refs:1 src-flags:added,contributing,active,
    path-list:[63] locks:36 flags:shared, uRPF-list:42 len:1 itfs:[1, ]
      path:[87] pl-index:63 ip4 weight=1 pref=0 attached-nexthop: oper-flags:resolved,
        192.168.11.8 HundredGigabitEthernet10/0/0
      [@0]: ipv4 via 192.168.11.8 HundredGigabitEthernet10/0/0: mtu:9000 next:6 flags:[]
525400111001525400121000800
    Extensions:
     path:87  labels:[[40 pipe ttl:0 exp:0]]
 forwarding:   mpls-neos-chain
  [@0]: dpo-load-balance: [proto:mpls index:58 buckets:1 uRPF:42 to:[0:0]]
    [0] [@6]: mpls-label[@52]:[40:64:0:neos]
      [@1]: mpls via 192.168.11.8 HundredGigabitEthernet10/0/0: mtu:9000 next:3
flags:[] 525400111001525400121008847
```
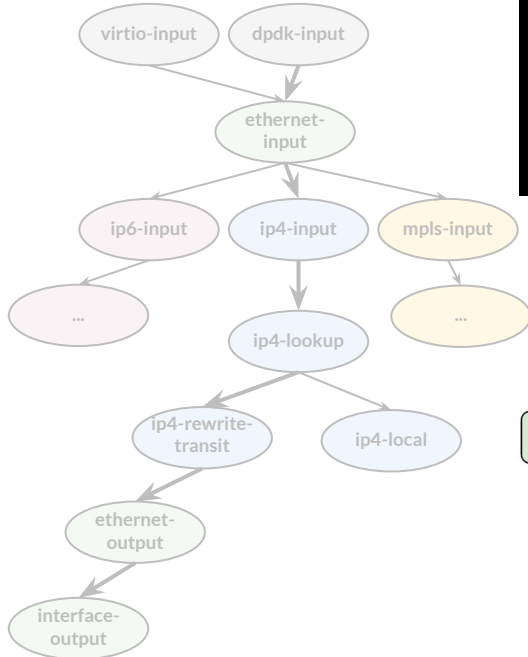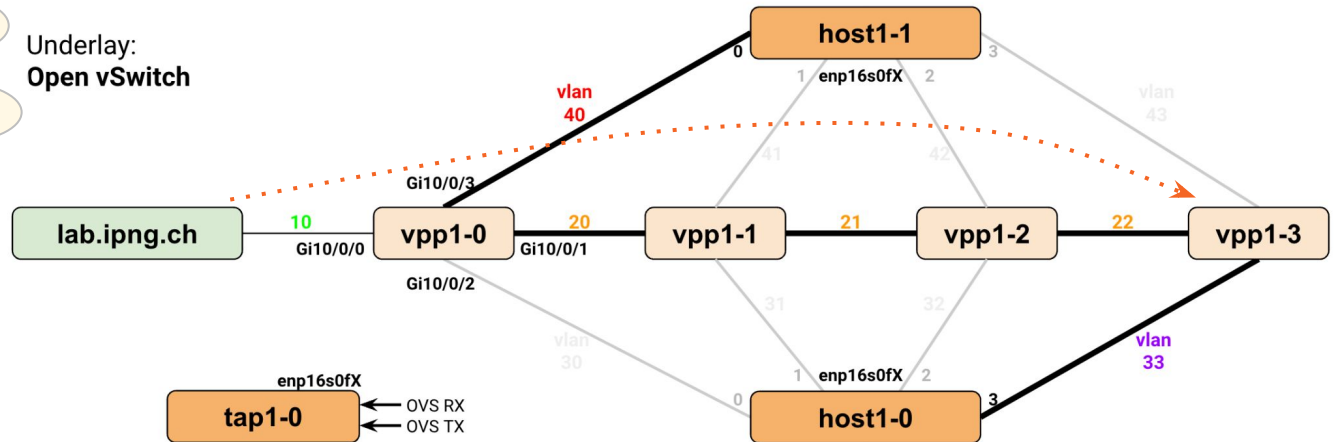
# VPP: With MPLS + Linux CP

```
pim@lab:~$ traceroute vpp1-3.lab.ipng.ch
traceroute to vpp1-3 (192.168.11.3), 30 hops max, 60 byte packets
 1  vpp1-3.lab.ipng.ch (192.168.11.3)  6.302 ms  6.201 ms  6.093 ms
```



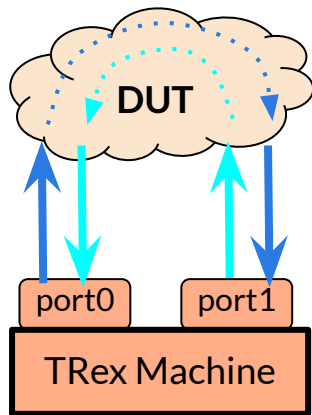Underlay:
**Open vSwitch**

# Act 2: Loadtesting MPLS in VPP

Dell R730 (2012)

# T-Rex: Config and Startup

**Simple configuration:**

```
- version: 2
  interfaces: ['5:00.0', '5:00.1']
  port_info:
      - src_mac    : 9c:69:b4:61:ff:40 # T-Rex Nic0
        dest_mac   : 3c:ec:ef:c6:fb:26 # DUT MAC A
      - src_mac    : 9c:69:b4:61:ff:41 # T-Rex Nic1
        dest_mac   : 3c:ec:ef:6a:80:db # DUT MAC B
```
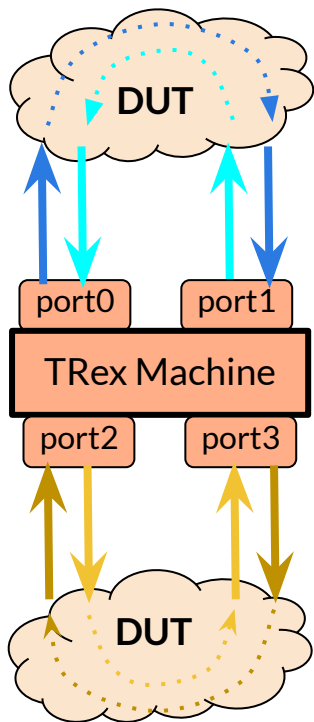
**Startup:**

```
$ sudo ./t-rex-64 -i -c 6
$ ./trex-console
```
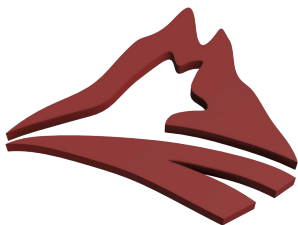
# T-Rex: Testing MPLS Performance



```python
class IPngStateless (object):
  def get_streams (self, port_id, direction, tunables, **kwargs):
    size, mpls = 64, True
    src, dst = f'16.0.{int(port_id/2)}.1', f'48.0.{int(port_id/2)}.1'
    if direction == 1:
      dst, src = src, dst

    vm_var = STLVM()
    vm_var.var(name='ip', min_value=0, max_value=255, size=1, op='random')
    vm_var.var(name='port', min_value=49152, max_value=65535, size=2, op='random')
    vm_var.write(fv_name='ip', pkt_offset='IP.src', offset_fixup=3)
    vm_var.write(fv_name='ip', pkt_offset='IP.dst', add_val=128, offset_fixup=3)
    vm_var.write(fv_name='port', pkt_offset='UDP.sport')
    vm_var.fix_chksum()
    vm_var.set_cached(1024)

    base_pkt = Ether()
    if mpls:
      base_pkt /= MPLS(label=16+port_id, cos=1, s=1, ttl=255)
    base_pkt /= IP(src=src, dst=dst)/UDP(dport=12, chksum=0)
    pad = max(0, size - len(base_pkt) - 4) * 'x'
    pkt = STLPktBuilder(pkt=base_pkt/pad, vm=vm_var)

    return [STLStream(packet=pkt, mode=STLTXCont(pps=1), isg=0.00, flow_stats=None)]
```
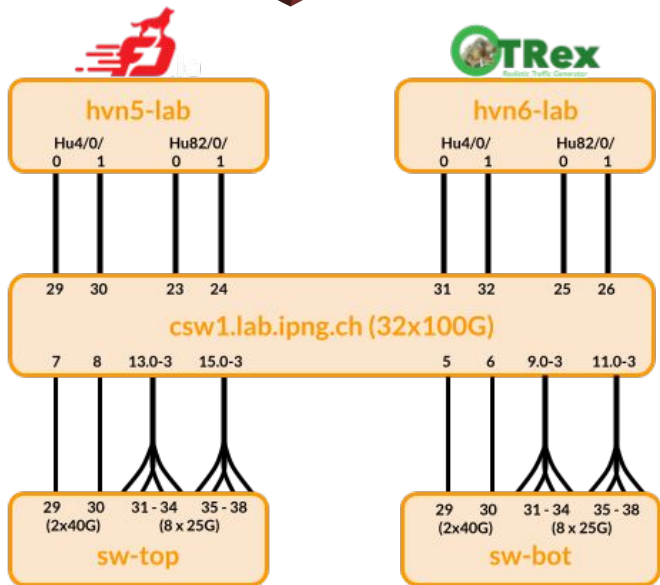
# IPng Lab: Physical topology



**Two Dell R730**
- Dual Xeon E5-2696 v4 - Broadwell @ 2.20GHz (44C/88T)
- 256G ECC DDR4 @2666MT/s
- 2x MCX516A-CDAT, linked at PCIe v3 x16 (4x100G)

**One Mellanox SN2700 (32x100G)**
- Running vanilla Debian w/ switchdev [ref]
- 24x100G, 16x25G (split ports)

**Two Centec S5612X**
- Runs MPLS, IPv4, IPv6, VxLAN, GENEVE in hardware [ref]
- 16x1G, 12x10G, 2x40G, 8x25G
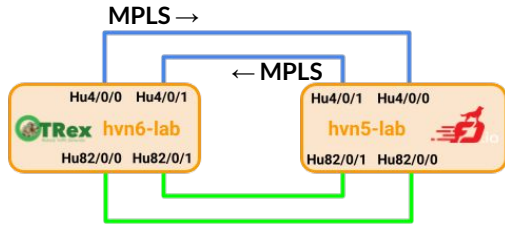
# VPP: MPLS Configuration (P Router)

```
pim@hvn5-lab:~$ vppctl

vpp# mpls table add 0
vpp# set interface mpls HundredGigabitEthernet4/0/0 enable
vpp# set interface mpls HundredGigabitEthernet4/0/1 enable
vpp# set interface mpls HundredGigabitEthernet82/0/0 enable
vpp# set interface mpls HundredGigabitEthernet82/0/1 enable

vpp# set int ip address HundredGigabitEthernet4/0/0 100.64.0.1/30
vpp# set int ip address HundredGigabitEthernet4/0/1 100.64.1.1/30
vpp# set int ip address HundredGigabitEthernet82/0/0 100.64.2.1/30
vpp# set int ip address HundredGigabitEthernet82/0/1 100.64.3.1/30

vpp# set ip neighbor HundredGigabitEthernet4/0/0 100.64.0.2 ec:0d:9a:83:20:6e
vpp# set ip neighbor HundredGigabitEthernet4/0/1 100.64.1.2 ec:0d:9a:83:20:6f
vpp# set ip neighbor HundredGigabitEthernet82/0/0 100.64.2.2 ec:0d:9a:83:22:d2
vpp# set ip neighbor HundredGigabitEthernet82/0/1 100.64.3.2 ec:0d:9a:83:22:d3

vpp# mpls local-label add 16 eos via 100.64.1.2 HundredGigabitEthernet4/0/1 out-labels 32
vpp# mpls local-label add 17 eos via 100.64.0.2 HundredGigabitEthernet4/0/0 out-labels 33
vpp# mpls local-label add 18 eos via 100.64.3.2 HundredGigabitEthernet82/0/1 out-labels 34
vpp# mpls local-label add 19 eos via 100.64.2.2 HundredGigabitEthernet82/0/0 out-labels 35
```
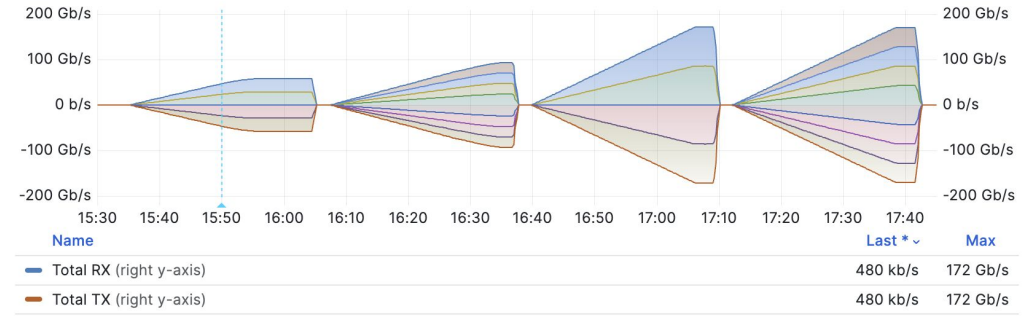
MPLS →

← MPLS

Hu4/0/0  Hu4/0/1          Hu4/0/1  Hu4/0/0

TRex  hvn6-lab          hvn5-lab

Hu82/0/0  Hu82/0/1        Hu82/0/1  Hu82/0/0

*Logical topology*
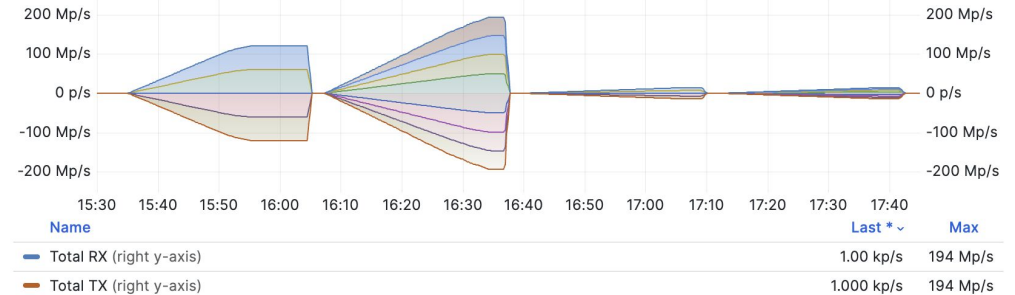
# VPP: MPLS Performance (P Router)

## MPLS LSR: Loadtest Results

1. **Unidirectional 64b**    58Gbps, 121Mpps
2. **Bidirectional 64b**      93Gbps, **194Mpps**
3. **Unidirectional 1514b**   **172Gbps**, 14.2Mpps
4. **Bidirectional 1514b**    171Gbps, 14.1Mpps



Interface L2 Bits/Sec

| Name | Last * ⌄ | Max |
| --- | --- | --- |
| Total RX (right y-axis) | 480 kb/s | 172 Gb/s |
| Total TX (right y-axis) | 480 kb/s | 172 Gb/s |

Interface Packets/Sec

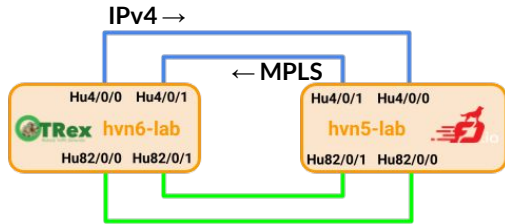| Name | Last * ⌄ | Max |
| --- | --- | --- |
| Total RX (right y-axis) | 1.00 kp/s | 194 Mp/s |
| Total TX (right y-axis) | 1.000 kp/s | 194 Mp/s |

# VPP: MPLS Configuration (PE Router)



```
pim@hvn5-lab:~$ vppctl

vpp# mpls table add 0
vpp# set interface mpls HundredGigabitEthernet4/0/0 enable
vpp# set interface mpls HundredGigabitEthernet4/0/1 enable
vpp# set interface mpls HundredGigabitEthernet82/0/0 enable
vpp# set interface mpls HundredGigabitEthernet82/0/1 enable

vpp# set int ip address HundredGigabitEthernet4/0/0 100.64.0.1/30
vpp# set int ip address HundredGigabitEthernet4/0/1 100.64.1.1/30
vpp# set int ip address HundredGigabitEthernet82/0/0 100.64.2.1/30
vpp# set int ip address HundredGigabitEthernet82/0/1 100.64.3.1/30

vpp# set ip neighbor HundredGigabitEthernet4/0/0 100.64.0.2 ec:0d:9a:83:20:6e
vpp# set ip neighbor HundredGigabitEthernet4/0/1 100.64.1.2 ec:0d:9a:83:20:6f
vpp# set ip neighbor HundredGigabitEthernet82/0/0 100.64.2.2 ec:0d:9a:83:22:d2
vpp# set ip neighbor HundredGigabitEthernet82/0/1 100.64.3.2 ec:0d:9a:83:22:d3

vpp# ip route add 16.0.0.0/24 via 100.64.0.2 HundredGigabitEthernet4/0/0 out-labels 33
vpp# ip route add 48.0.0.0/24 via 100.64.1.2 HundredGigabitEthernet4/0/1 out-labels 32
vpp# ip route add 16.0.1.0/24 via 100.64.2.2 HundredGigabitEthernet82/0/0 out-labels 34
vpp# ip route add 48.0.1.0/24 via 100.64.3.2 HundredGigabitEthernet82/0/1 out-labels 35
```

# VPP: MPLS Performance (PE Router)

## MPLS LER: Loadtest Results

**1. Unidirectional 64b**

In: 47.8Gbps, Out: 51.0Gbps, 99.5Mpps

**2. Bidirectional 64b**

In: 86.4Gbps, Out: 91.8Gbps, **179Mpps**

**3. Unidirectional 1514b**

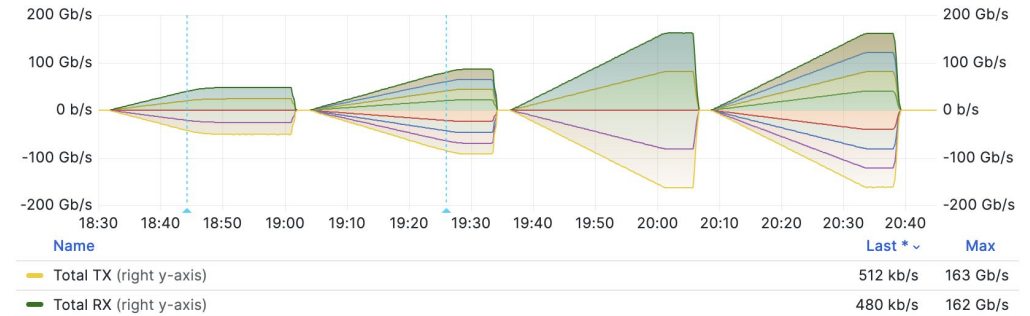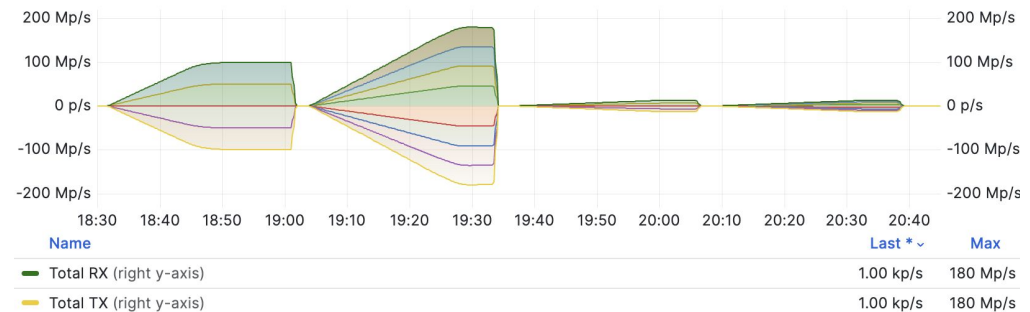In: **162Gbps**, Out: 163Gbps, 13.4Mpps

**4. Bidirectional 1514b**

In: 162Gbps, Out: 163Gbps, 13.4Mpps

*) Out > In due to MPLS encapsulation overhead



vpp v24.02-rc0~182-g60fc4e3bf built by pim on summer at 2023-12-13T12:00:24

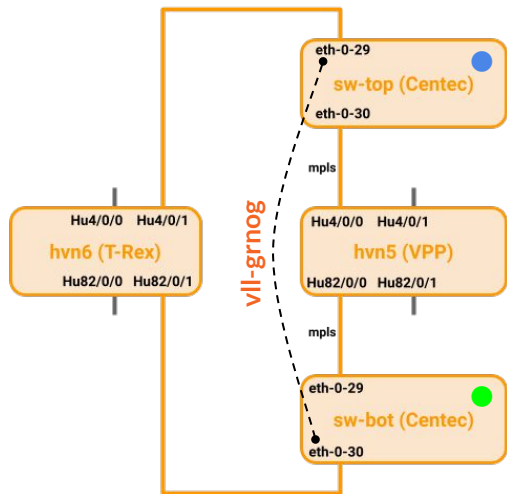# Act 3: VPP MPLS interoperability

Centec S5612X
(2023)

Dell R730
(2012)

# VPP: MPLS as LSR (P-Router)



```
sw-top.lab# show run int eth-0-29
interface eth-0-29
 description Core: csw1.lab:swp7
 mpls-l2-circuit vll-grnog ethernet

mpls l2-circuit vll-grnog 829800 192.0.2.2 raw mtu 1500
router ldp
 router-id 192.0.2.0
 targeted-peer 192.0.2.2


sw-bot.lab# show run int eth-0-30
interface eth-0-30
 description Core: csw1.lab:swp6
 mpls-l2-circuit vll-grnog ethernet

mpls l2-circuit vll-grnog 829800 192.0.2.0 raw mtu 1500
router ldp
 router-id 192.0.2.2
 targeted-peer 192.0.2.0
```
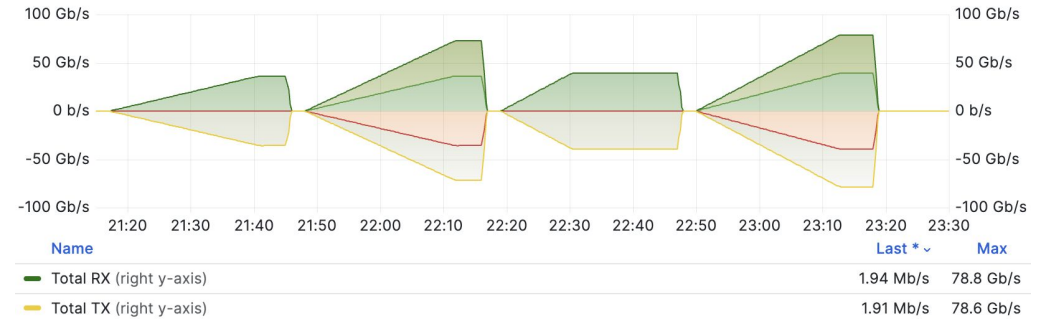
# VPP: MPLS Performance (P Router)
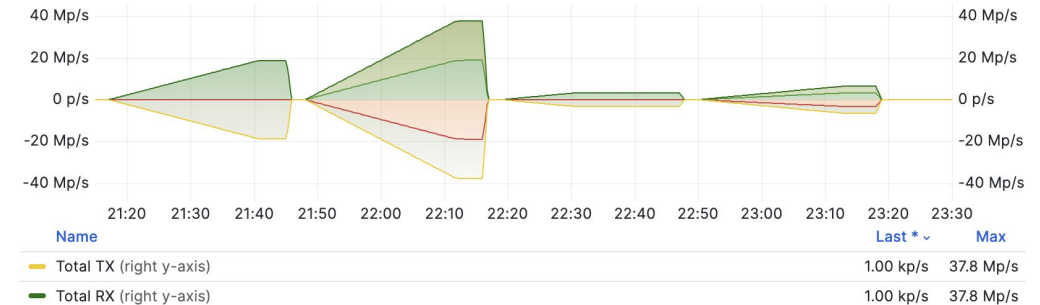
## MPLS LSR Interop: Loadtest Results

**1. Unidirectional 256b**   36.4Gbps, 18.8Mpps

**2. Bidirectional 256b**   72.8Gbps, 37.8Mpps

**3. Unidirectional 1514b**   39.4Gbps, 3.21Mpps

**4. Bidirectional 1514b**   78.8Gbps, 6.43Mpps

*) Note: 40G between Centec and VPP



Interface L2 Bits/Sec

| Name | | Last * ⌄ | Max |
|---|---|---|---|
| ■ Total RX (right y-axis) | | 1.94 Mb/s | 78.8 Gb/s |
| ■ Total TX (right y-axis) | | 1.91 Mb/s | 78.6 Gb/s |

Interface Packets/Sec

| Name | | Last * ⌄ | Max |
|---|---|---|---|
| ■ Total TX (right y-axis) | | 1.00 kp/s | 37.8 Mp/s |
| ■ Total RX (right y-axis) | | 1.00 kp/s | 37.8 Mp/s |

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# VPP: MPLS as LER (PE-Router)



```
sw-top.lab# show run int eth-0-30
interface eth-0-29
 description Core: csw1.lab:swp7
 mpls-l2-circuit vll-north ethernet

sw-top.lab# show run | inc mpls l2-circuit
mpls l2-circuit vll-north 829801 192.0.2.1 mtu 1522 manual
mpls l2-circuit-fib-entry vll-north 128 18
```
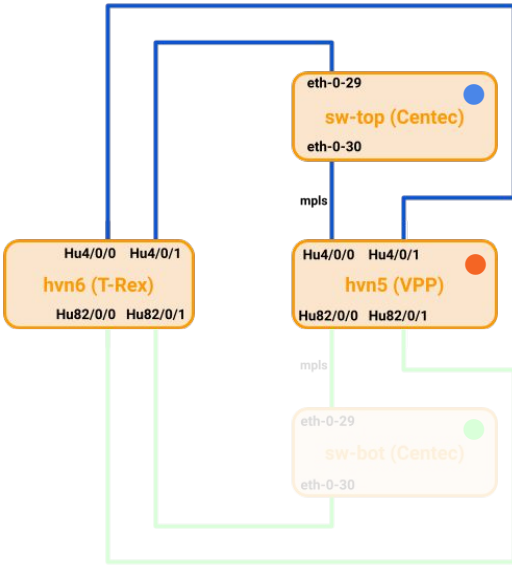
ingress       egress

# VPP: MPLS as LER (PE-Router)



```
sw-top.lab# show run int eth-0-30
interface eth-0-29
 description Core: csw1.lab:swp7
 mpls-l2-circuit vll-north ethernet

sw-top.lab# show run | inc mpls l2-circuit
mpls l2-circuit vll-north 829801 192.0.2.1 mtu 1522 manual
mpls l2-circuit-fib-entry vll-north 128 18


sw-bot.lab# show run int eth-0-30
interface eth-0-30
 description Core: csw1.lab:swp6
 mpls-l2-circuit vll-south ethernet

sw-bot.lab# show run | inc mpls l2-circuit
mpls l2-circuit vll-south 829802 192.0.2.1 mtu 1522 manual
mpls l2-circuit-fib-entry vll-south 129 20
```
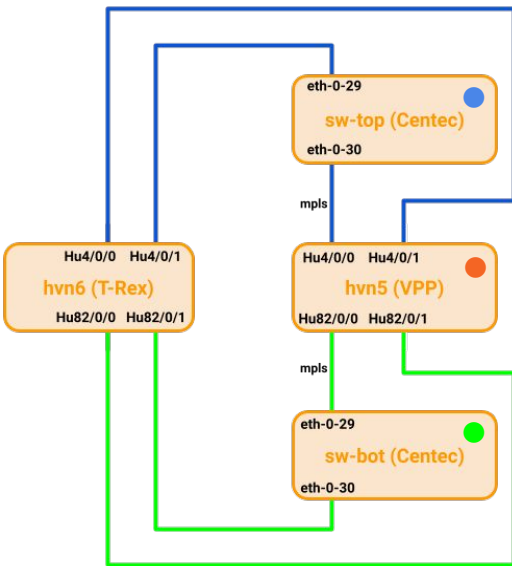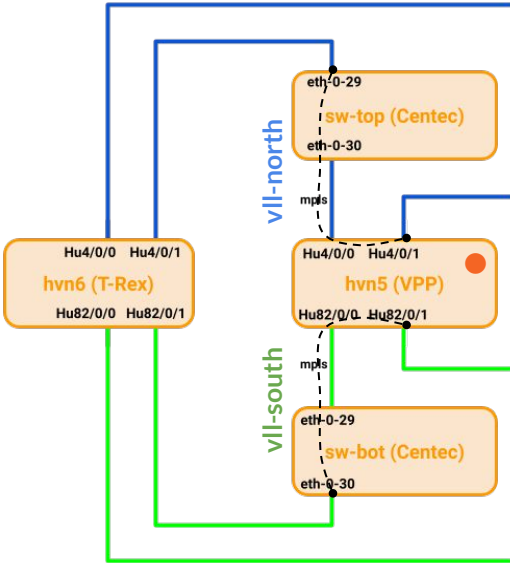
# VPP: MPLS as LER (PE-Router)

```
pim@hvn5-lab:~$ vppctl

vpp# mpls tunnel l2-only via 192.0.2.0 out-labels 128
vpp# mpls local-label 18 eos via l2-input-on mpls-tunnel0
vpp# set int l2 xconnect mpls-tunnel0 HundredGigabitEthernet4/0/1
vpp# set int l2 xconnect HundredGigabitEthernet4/0/1 mpls-tunnel0
vpp# set interface state HundredGigabitEthernet4/0/1 up
vpp# set interface state mpls-tunnel0 up


vpp# mpls tunnel l2-only via 192.0.2.2 out-labels 129
vpp# mpls local-label 20 eos via l2-input-on mpls-tunnel1
vpp# set int l2 xconnect mpls-tunnel1 HundredGigabitEthernet82/0/1
vpp# set int l2 xconnect HundredGigabitEthernet82/0/1 mpls-tunnel1
vpp# set interface state HundredGigabitEthernet82/0/1 up
vpp# set interface state mpls-tunnel1 up
```

# VPP: MPLS Performance (PE Router)

## MPLS LER Interop: Loadtest Results

**1. Unidirectional 256b**

  In: 72.1Gbps, Out: 78.0Gbps, 41.0Mpps

**2. Bidirectional 256b**

  In: 141Gbps, Out: 143Gbps, 77.6Mpps
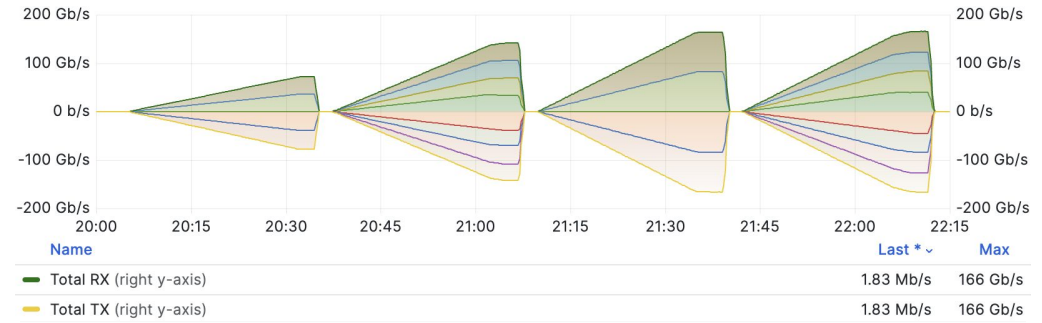
**3. Unidirectional 1514b**

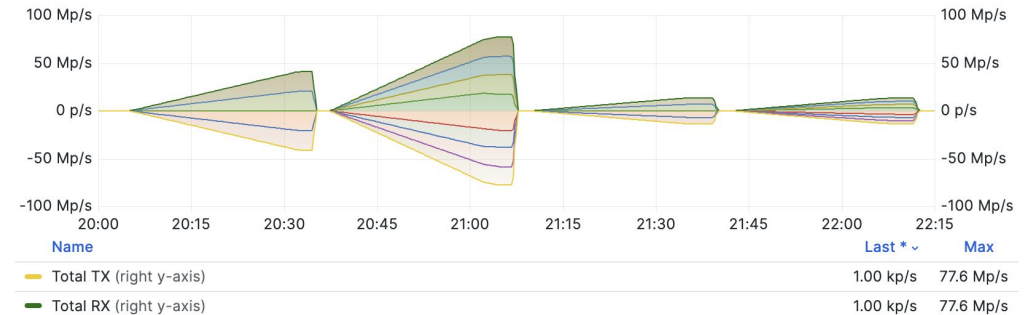  In: 164Gbps, Out: 166Gbps, 13.6Mpps

**4. Bidirectional 1514b**

  In: 164Gbps, Out: 166Gbps, 13.6Mpps

*) Note:  40G between Centec and T-Rex/VPP

  100G between T-Rex and VPP
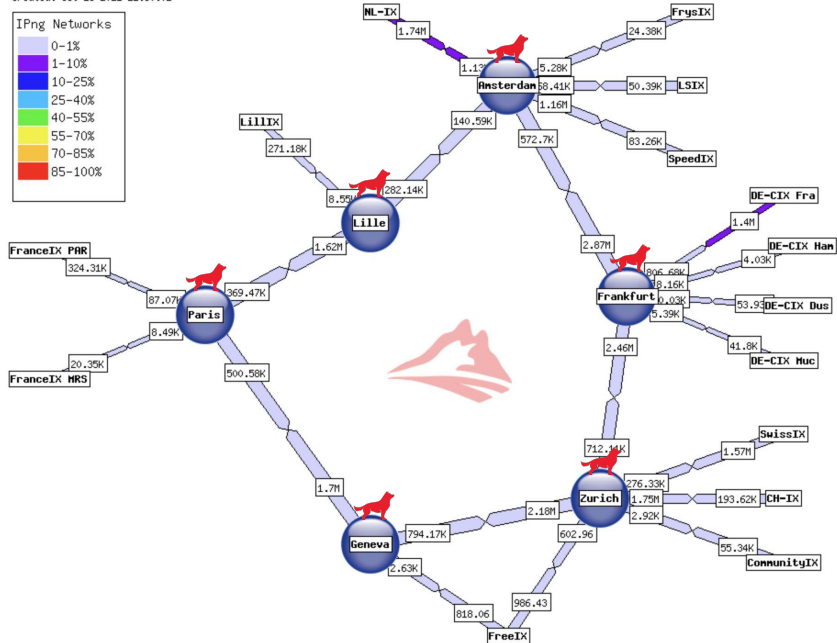


Interface L2 Bits/Sec

| Name | Last * ⌄ | Max |
|------|------|-----|
| Total RX (right y-axis) | 1.83 Mb/s | 166 Gb/s |
| Total TX (right y-axis) | 1.83 Mb/s | 166 Gb/s |

Interface Packets/Sec

| Name | Last * ⌄ | Max |
|------|------|-----|
| Total TX (right y-axis) | 1.00 kp/s | 77.6 Mp/s |
| Total RX (right y-axis) | 1.00 kp/s | 77.6 Mp/s |

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# Questions, Discussion



Created: Oct 16 2021 21:30:02

IPng Networks
- 0-1%
- 1-10%
- 10-25%
- 25-40%
- 40-55%
- 55-70%
- 70-85%
- 85-100%

**If you peer with IPng Networks, thanks!
If you don't: please peer with AS8298**
<peering@ipng.ch>

## Useful Resources

- **VPP Mailinglist** [vpp-dev@lists.fd.io]
- **VPP Linux CP** [GitHub]
- **Articles** [ipng.ch]
- **Mastodon** [@IPngNetworks]

Also: thanks for listening!